

Predictors of radiation dose associated with Coronary CT Angiography

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Purpose

1. Coronary computed tomography angiography (CCTA) has become a robust noninvasive diagnostic imaging modality in the examination of coronary artery disease. The number of cardiac diagnostic tests that are performed has increased significantly in recent years.
2. The new generation multidetector-row CT scanners have a very high diagnostic accuracy and negative predictive value (>98%) in detecting significant coronary stenosis as compared to the invasive coronary angiography (ICA). The high spatial- and high temporal resolution permit a powerful non-invasive visualisation of the coronary arteries.
3. The ionizing radiation can be deteriorative effect on human body, thus the implementation of radiation dose reduction strategies in daily practice is of utmost importance (Ref. 2-3) Fast-paced technical innovations provide new opportunities for radiation dose reduction, among others iterative reconstruction techniques could potentially decrease the dose of radiation without loss of diagnostic information and improves spatial resolution at low dose. (Ref.4-5) [Fig. 1](#) on page 2
4. Our aim was to assess the radiation dose associated with CCTA performed with 256-slice CT scanner (256-CCTA) in routine clinical practice, furthermore to investigate the independent factors associated with increased radiation dose.

Images for this section:

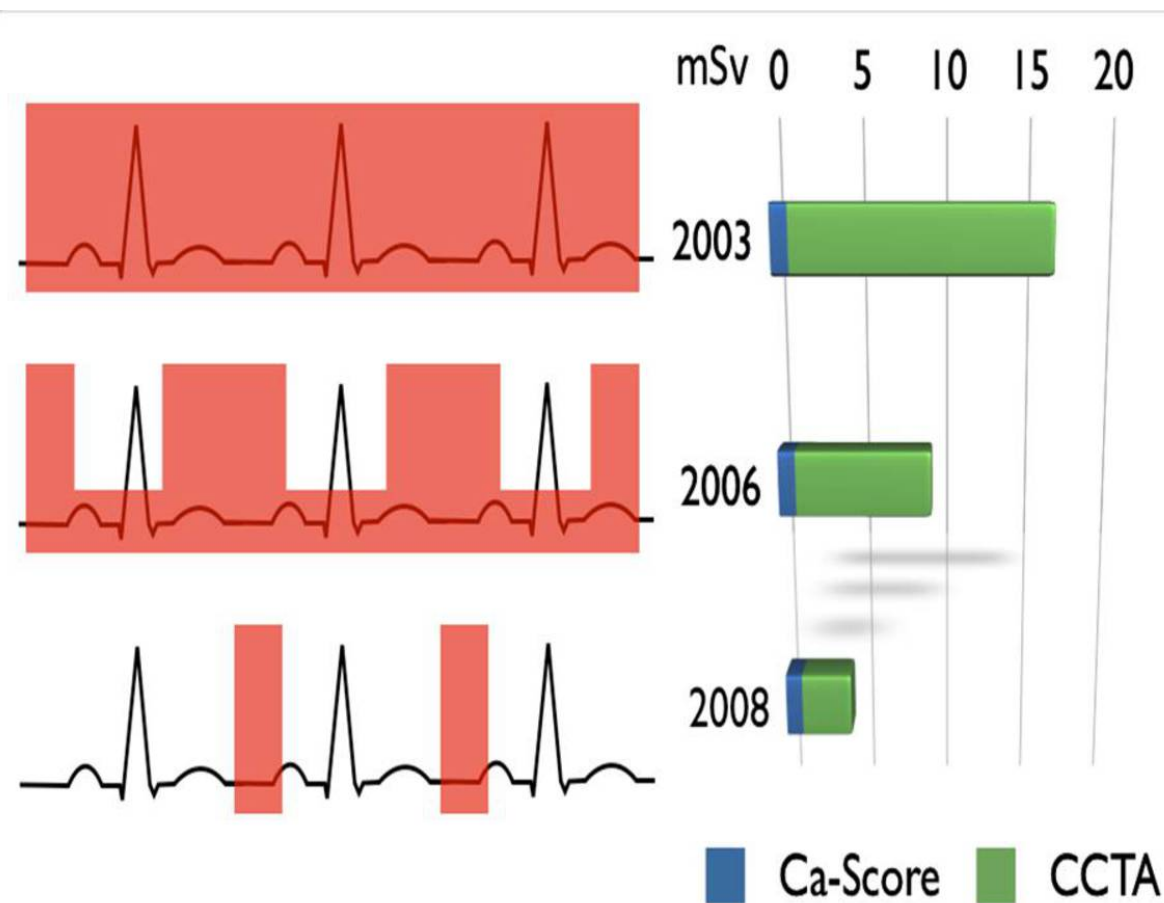


Fig. 1: ECG gating and the associated radiation doses. Top row: Retrospective ECG gating Middle row: Retrospective ECG gating with dose modulation Bottom row: Prospective ECG triggering CCTA: Coronary Computed Tomography Angiography

Methods and Materials

We estimated the radiation dose of 1143 patients who underwent 256-CCTA at the Heart Center, Semmelweis University between February 2011 and November 2012 [Fig. 2](#) on page 7. Radiation dose parameters were extracted from the dose exposure records and scan reports were used to collect patients' baseline characteristics [Table 1](#) on page 4. The DLP (dose length product), a standard measure of the total amount of radiation was recorded (Ref.6). The DLP was converted into millisieverts by multiplying it by a body region-specific scaling factor (k-factor=0.014) (Ref. 7 and 8).

Data analysis was performed using Statistica version 11 (StatSoft, Inc., Tulsa, OK). All continuous variables were expressed as mean $\pm$ SD or median with interquartile ranges, whereas categorical variables were expressed as percentage. Differences in continuous variables were assessed using Student paired t test or Mann-Whitney U test as appropriate.

We have analyzed the data of 1143 consecutive patients (674 male, 59%). The mean age was 59($\pm$ 11.8) years, 552 (48%) patients are older than 60 years. We measured body parameters of patients (height and weight), and calculated the Body Mass Index. The median BMI was 27,7 [IQR:25-31]. We found that 262 patients had a lower BMI than 25 (23%), 541 patients are between 25-30 (47%), and 334 patients are above 30 (30%). 986 of 1143 CT-scans (86%) were performed with prospective triggering acquisition scan mode with 3% padding. The heart rate was available of 832 patients (Ref.9). The average contrast material application was 90 ml [IQR:90-95]. [Fig. 3](#) on page 5 [Fig. 4](#) on page 6

Images for this section:

N=1143	
Age (Mean±SD)	59(± 11.8) years
Gender	674 male (59%);469 female (41%)
BMI (Mean; IQR)	27,7 (25-31)
BMI under 25	262 (23%)
25-30	541 (47%)
above 30	334 (30%)
Contrast material	90 ml (90-95)
Prospective gating	986 (86%)

Table 1

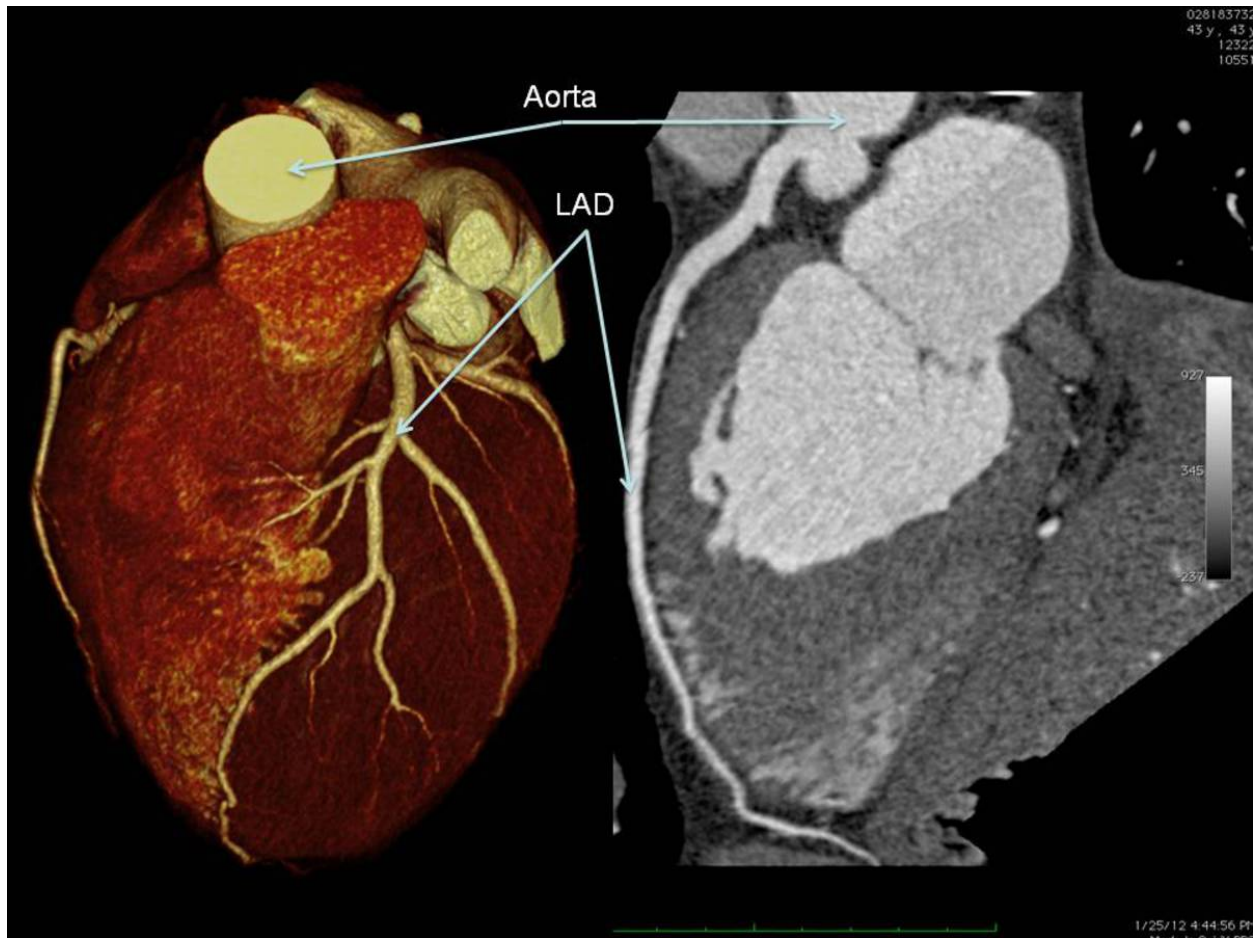


Fig. 3: 43 years old male patient, active athlete. Left Panel: Volumen rendered image. Right panel: curved multiplanar reconstruction of LAD. Radiation dose: 2.1 mSv (DLP: 150 mGyxcm)

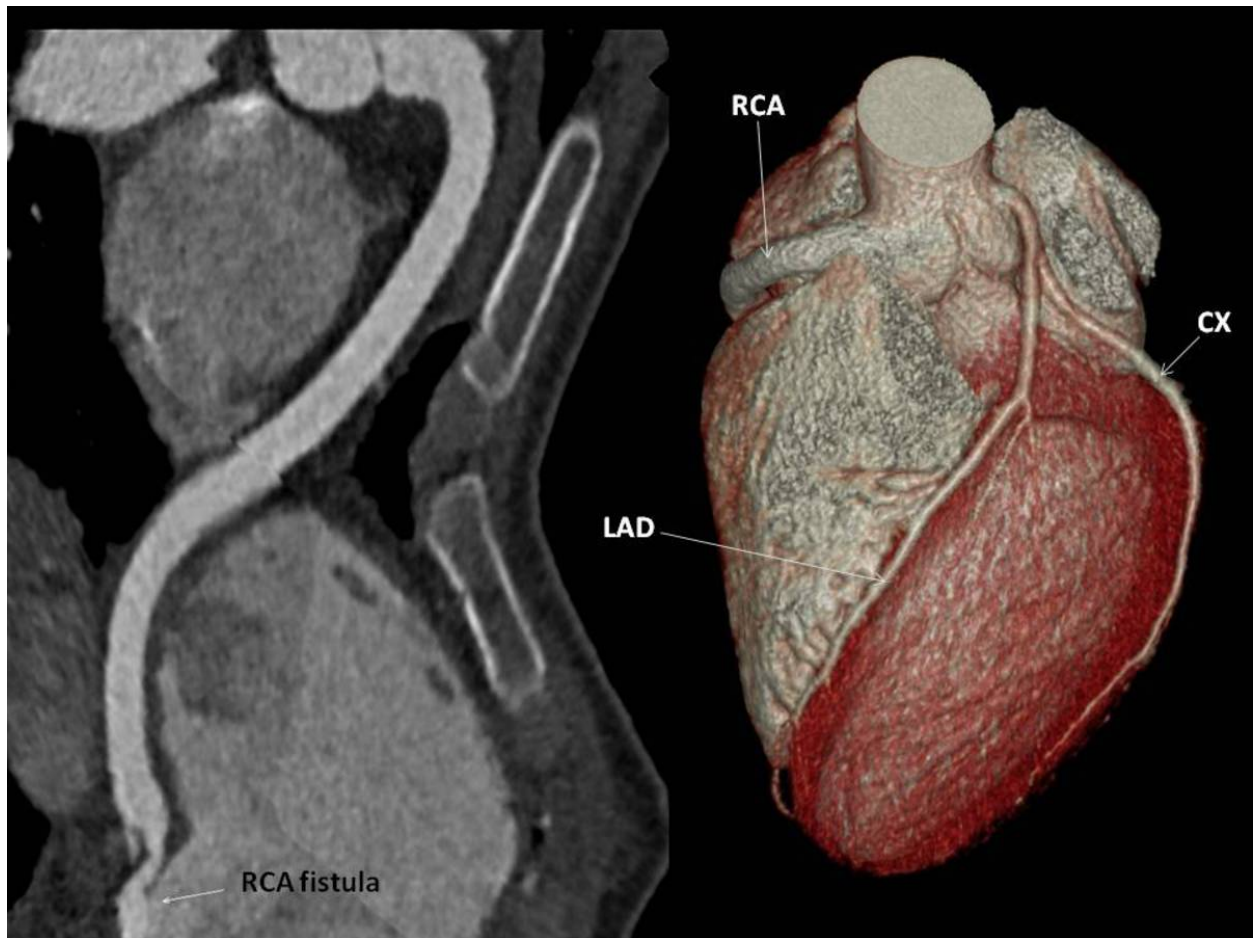


Fig. 4: 19 years old female patient. Left panel: curved multiplanar reconstruction of RCA using iterative reconstruction. Right Panel: Volumen rendered image using iterative reconstruction. Radiation dose: 0.41 mSv (DLP: 29.5 mGyxcn)

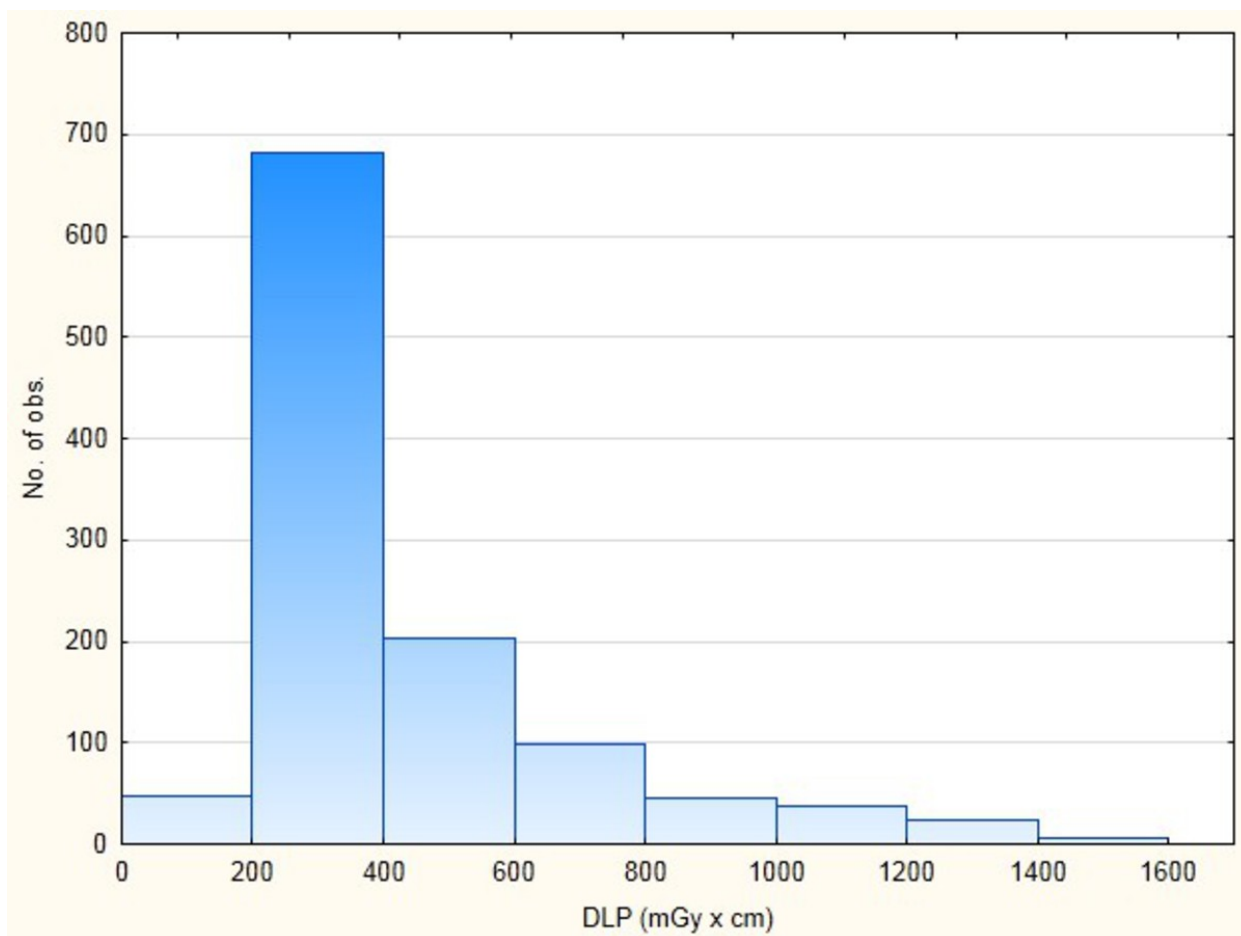


Fig. 2: The distribution of radiation doses associated with coronary CT angiography in the Heart Center, Semmelweis University. Median DLP: 381 mGy x cm.

Results

We performed 1143 CCTA scans, and the median DLP was 381 [364-471] mGyxcn, corresponding to an estimated effective radiation dose of 5.3 mSv.

We found significant difference in radiation doses related to the following variables:

- heart rate: low (<65/bpm) vs high (≥65/bpm), 378[360-390] vs 443[374-711] mGyxcn, $p<0.0001$; [Fig. 8](#) on page 12
- normal weight (BMI<25) vs overweight (BMI>25), 365[238-384] vs 384[372-496] mGyxcn, $p<0.0001$; [Fig. 5](#) on page 9
- patients under vs above 60 years 377[313-423] vs 385[373-543] mGyxcn, $p<0.0001$; [Fig. 6](#) on page 10
- prospective vs retrospective gating 379[361-411] vs 896[706-1073] mGyxcn, $p<0.0001$; [Fig. 9](#) on page 13
- men vs women 385[371-502] vs 377[340-437] mGyxcn, $p<0.0001$; [Fig. 7](#) on page 11
- filtered back projection (FBP) vs iterative reconstruction, 384[372-496] vs 369[269-379] mGyxcn, $p<0.0001$. [Fig. 10](#) on page 14

Independent factors associated with radiation dose were HR ($p<0.0001$), BMI ($p<0.0001$), age ($p<0.0001$), gender ($p<0.0001$), gating ($p<0.0001$) and reconstruction technique ($p<0.0001$).

Images for this section:

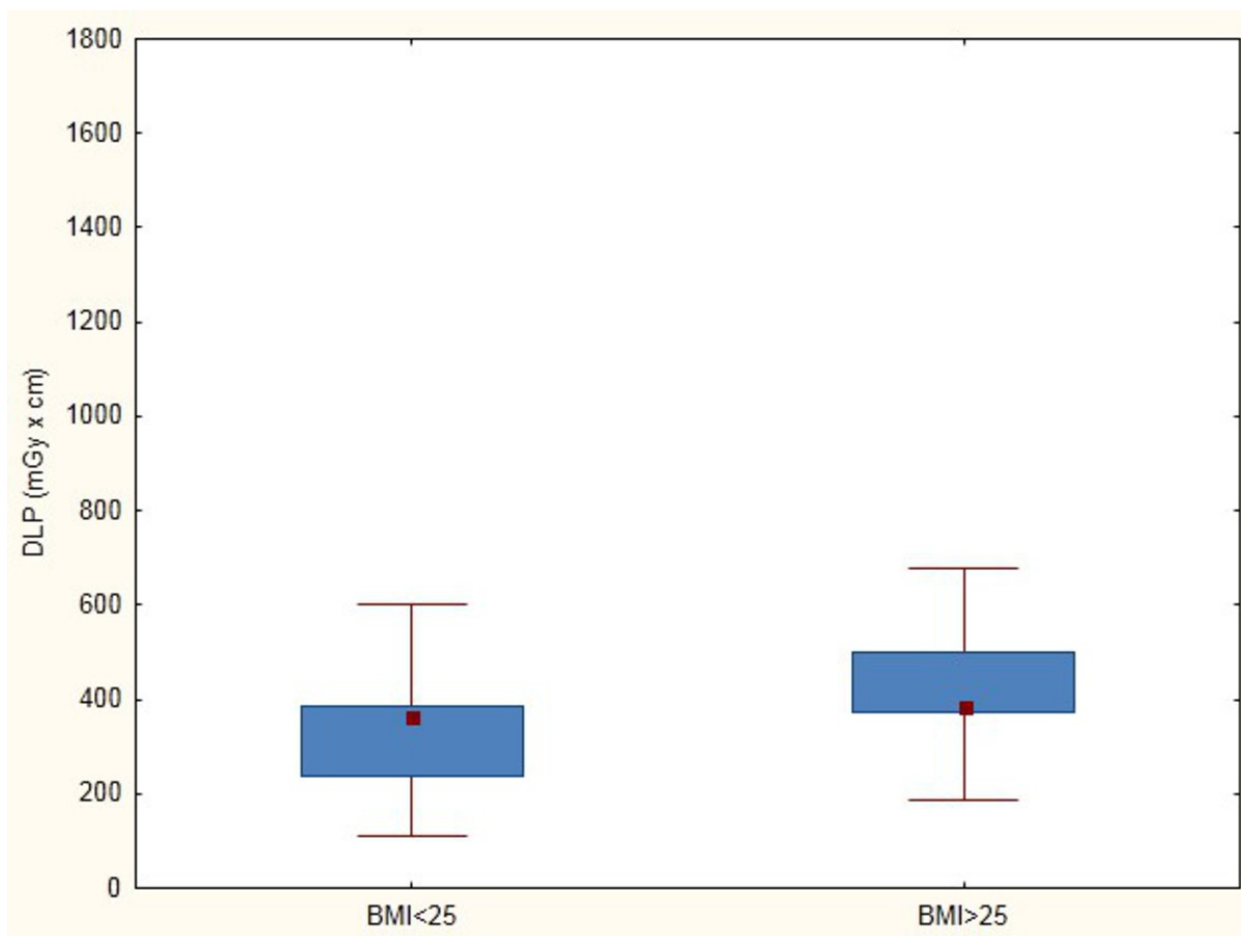


Fig. 5: Radiation doses associated with body weight. Normal weight patients (BMI < 25 kg/m²), (365 [238-384] versus 384 [372-496] mGy x cm).

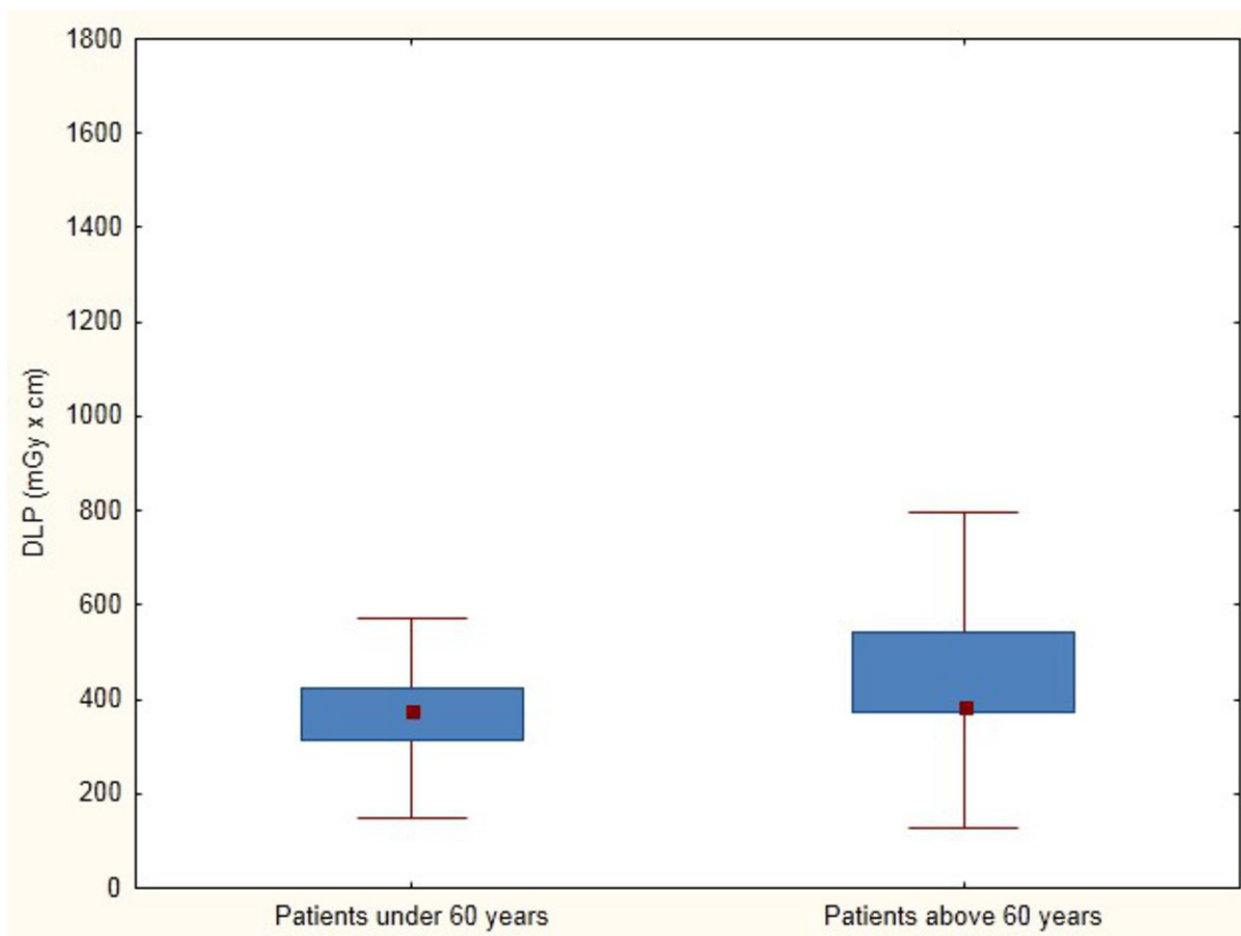


Fig. 6: Radiation doses associated with age, patients under 60 years versus patients above 60 years (377 [313-423] versus 385 [373-543] mGy x cm).

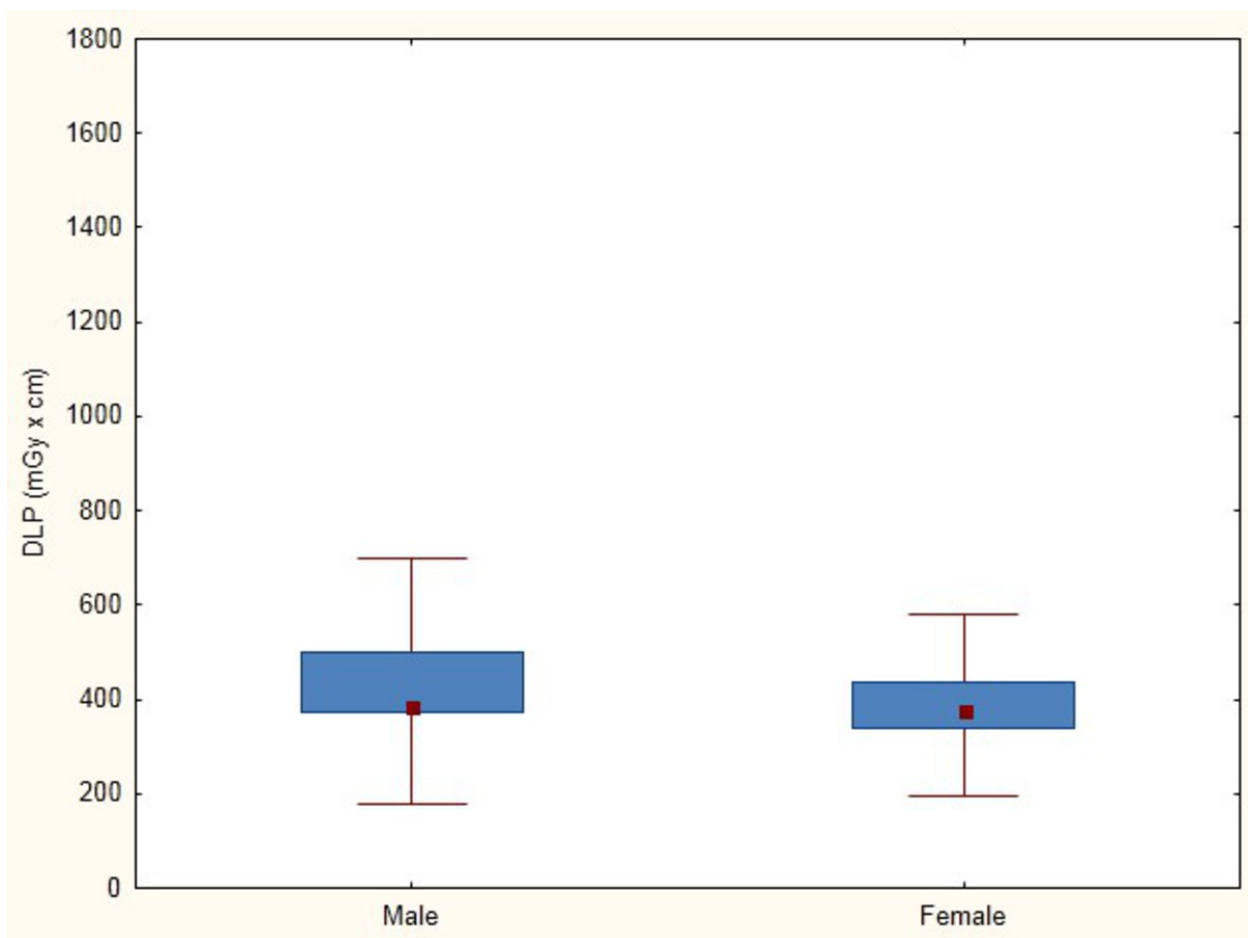


Fig. 7: Radiation doses associated with gender, female versus male (377 [340-437] versus 385 [371-502] mGy x cm).

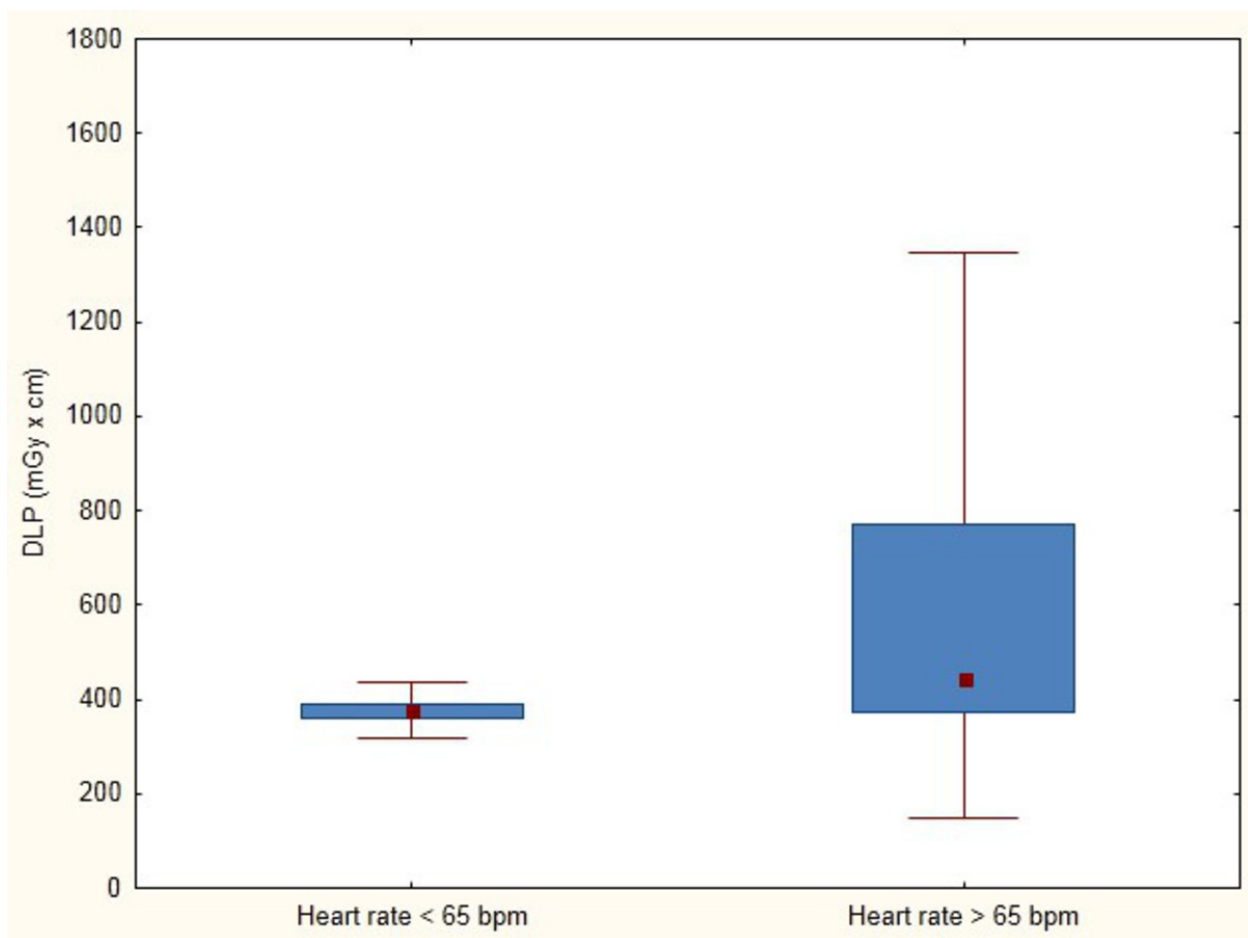


Fig. 8: Radiation doses associated with heart rate, patients under 65 bpm versus patients above 65 bpm (378 [360-390] versus 443 [374-711] mGy x cm).

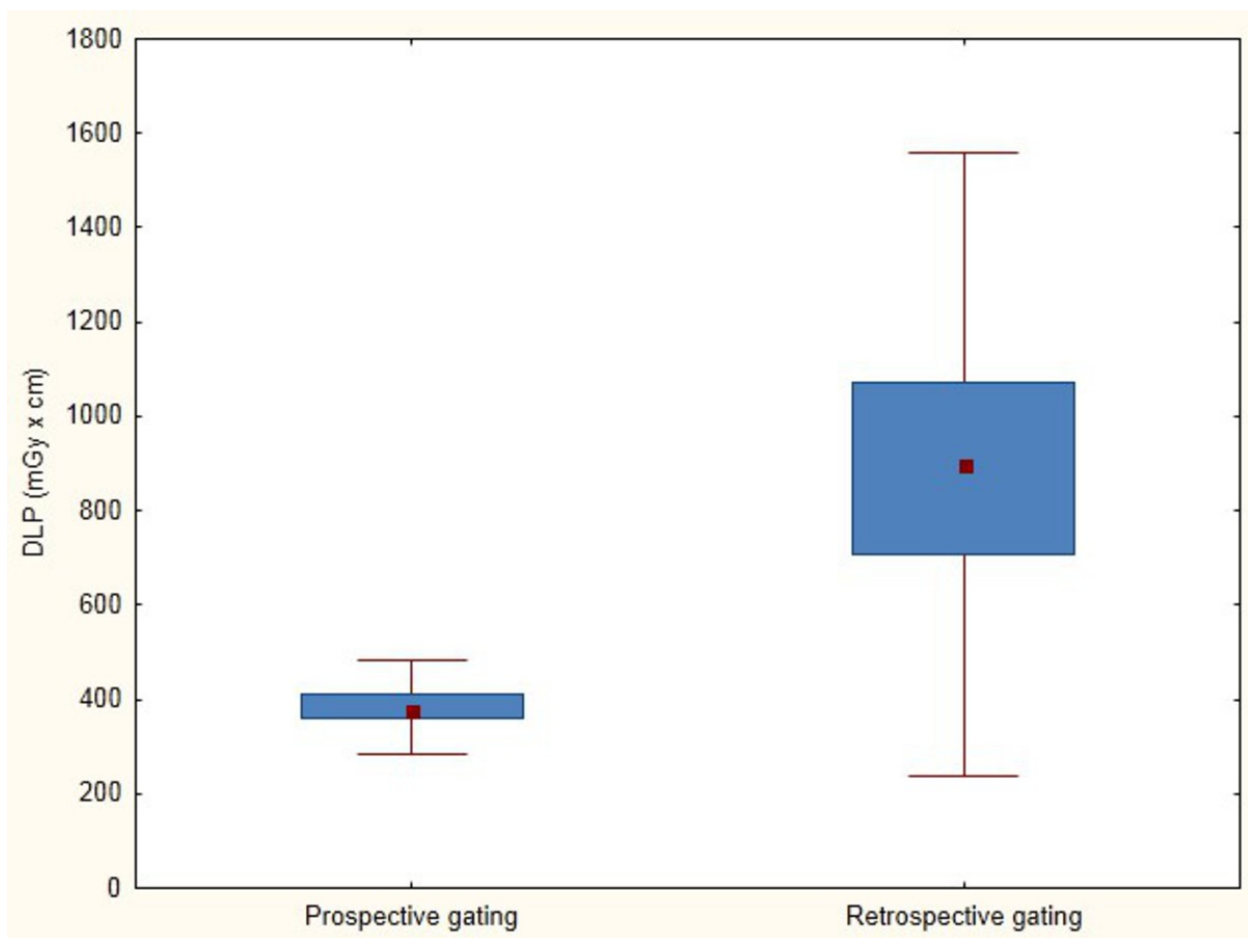


Fig. 9: Radiation doses associated with prospective gating versus retrospective gating (379 [361-411] versus 896 [706-1073] mGy x cm).

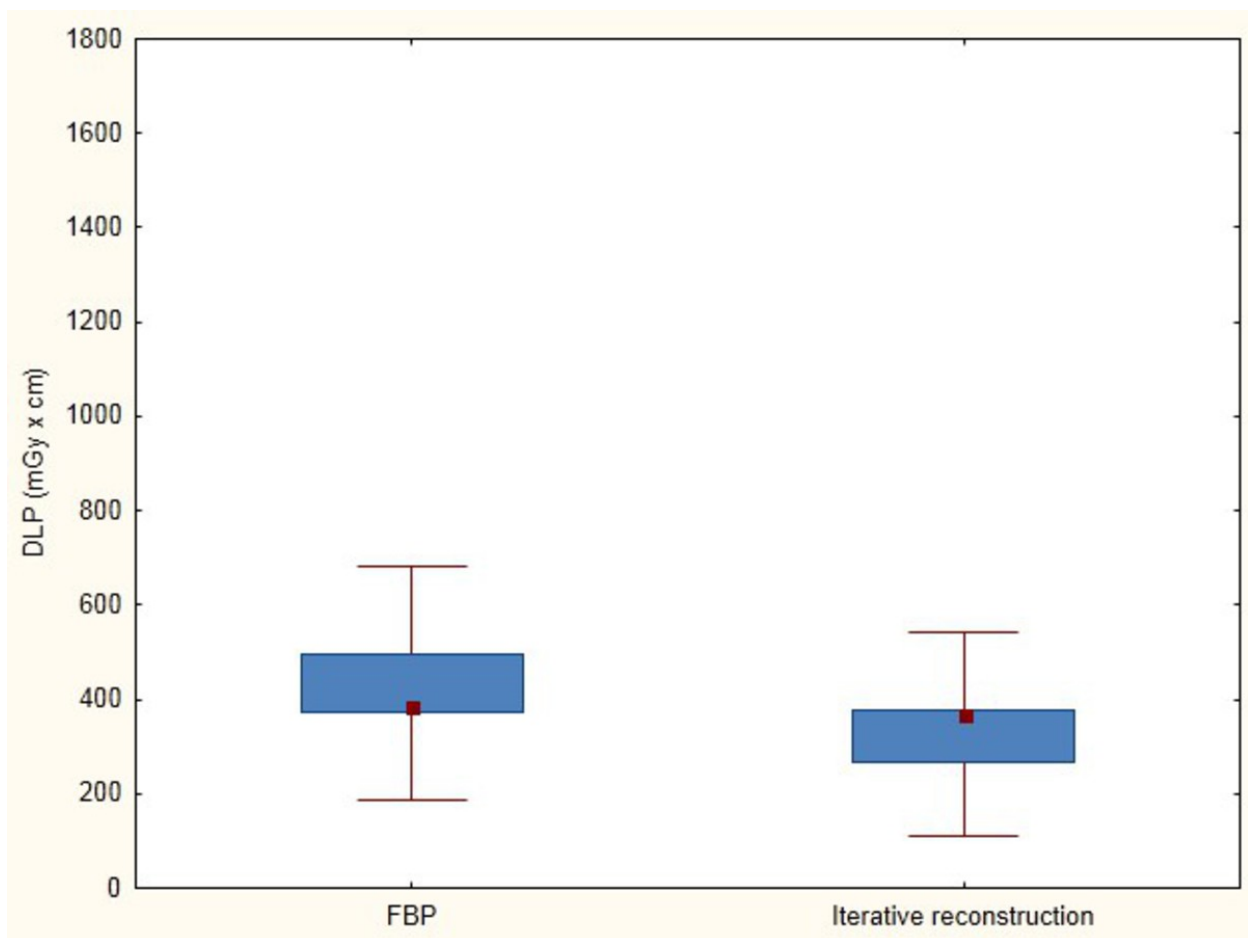


Fig. 10: Radiation doses associated with reconstruction technique, filtered back projection versus iterative reconstruction (384 [372-496] versus 369 [269-379] mGy x cm).

Conclusion

Our findings demonstrate that 256-CCTA can be performed with low radiation dose (5.3 mSv) in routine clinical practice, which is lower than in other routine CT diagnostic procedures. (~50% of abdominal CT and 20% of myocardium perfusion scintigraphy).

At our institute, the independent factors associated with radiation dose reduction were HR, BMI, younger age, gender, step-and-shoot scanning mode and iterative reconstruction technique.

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